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# Evaluation of vascular access complications in acute and chronic hemodialysis

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**ABSTRACT:** ***Purpose:*** **This work aimed to determine the incidence of vascular access (VA)-related complications of temporary venous catheters in acute hemodialysis (HD) prescription, to study the survival rate of chronic HD patients who began HD with a catheter insertion and to evaluate associated complications.**
***Methods:*** **The patients were classified into two groups. Group I, patients in whom venous catheters were inserted (652 patients). Group II, 80 patients with end-stage renal disease (ESRD) in whom an arteriovenous fistula (AVF) was established.**
***Results:*** **Complications in the femoral approach were bleeding from a femoral artery wall laceration in only 6/600 patients (1%), successfully repaired in all patients, bleeding from a punctured femoral artery in 30 patients (5%), the incidence of infection and removal was 40%. Other complications included groin hematoma in 3 patients (0.5%) and catheter thrombosis in 45 patients (7.5%). In the jugular vein approach, infection occurred in 6/30 patients (20%), thrombosis in 9 patients (30%), and accidental withdrawal in 2 patients (6.7%). In the subclavian vein approach, catheter dysfunction was found in 7/22 patients (32%), infection in 10 patients (45.5%), and failure to cannulate the vein in 3 patients (13.6%). In group II, limb edema was found in 14/80 patients (17.5%), hematoma in 5 patients (6.3%), accidental trauma to the fistula in 2 patients (2.5%) and fistula stenosis in 15 patients (18.8%). Patients who began HD with a catheter had higher mortality than those who began with an AVF (12 months survival, respectively, 60 vs. 83%).**
***Conclusion:*** **Patients who began HD with a catheter had more complications and higher mortality. Routine quality assessment of AVF by Doppler ultrasound is recommended. (The Journal of Vascular Access 2004; 5: 76-82)**

**KEY WORDS:** *Vascular access, Hemodialysis*

## INTRODUCTION

After decades of success in dialysis research and treatment, the prompt availability of a well functioning vascular access (VA) for dialysis remains a disturbing problem (1). VA complications account for 16-25% of hospital admissions in hemodialysis (HD) patients (2). HD VA dysfunction is a major cause of morbidity and hospitalization among the HD population (3). Catheter dysfunction is defined as the absence of an adequate flow through the catheter lumen (4).
The necessity of VA in patients with renal failure can be temporary or permanent. The need for temporary access can vary from several hours (single dialysis) to weeks if used to dialyze while waiting for an arteriovenous fistula (AVF). Temporary access is established by the percutaneous insertion of a catheter into a large vein (5). Femoral vein cannulation is the safest method of acute VA (6) and it is our preferred solution if a temporary vascular dialysis is considered (7). Recent technical improvements have made this approach more reliable because the new femoral catheters can remain in place for relatively long periods (8).
Venous catheters are commonly used for acute HD prescription in the following patients: patients with acute renal failure, patients with chronic renal failure who need urgent HD, but without available mature access, patients on maintenance HD who have lost their permanent access function and require temporary access until a permanent access function can be re-established, and peritoneal dialysis patients whose abdomens are being rested prior to new peritoneal catheter placement (5).
AVF are the preferred VA for chronic HD prescrip-

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tion (9). An AVF consists of a subcutaneous anastomosis of an artery to an adjacent vein. The anastomosis can be made either side of artery to side of vein or side of artery to end of vein. The most common AVF locations are radiocephalic (wrist), brachiocephalic (elbow), or brachiobasilic transposition (10).

Low resistance in the venous system leads to a substantial blood flow increase in the artery; and therefore, in the communicating vein. The artificially induced high venous blood flow leads to the dilatation of the vein and to the thickening of its wall, providing a VA segment that can be punctured several times a week with a large gauge needle for performing HD (11).

The high frequency of access problems requires an examination method that is accurate, non-invasive and that can be repeated as often as needed to evaluate fistula morphology and function. Dikow et al (12) recommended that fistula flow should be monitored by duplex sonography for evaluating HD access problems.

Color flow Doppler provides accurate imaging and access flow measurement of the HD VA. It can readily identify subsets of patients at risk of future thrombosis. It is non-invasive, mobile and allows convenient clinical evaluation of the arteriovenous dysfunction. It can also diagnose the arterial inflow disease. Access management programs based on Doppler ultrasound have been highly successful and have produced outcome data as good as or better than that provided by other techniques. Clinical outcome data and direct comparison with other modalities support this (13). Garland et al (14) also reported that the best method for access measurement was ultrasonography.

Many patients are usually given intravenous fluids such as glucose solution, as they often have marked anorexia. This leads to unnecessary damage to the veins of the upper limbs, which makes fistula creation for HD difficult for the vascular surgeon (15).

This study aimed to determine VA-related complications in acute HD prescriptions in those patients who used venous catheters, and chronic HD patients with an AVF.

## METHODS

This study was carried out from October 2000 to September 2003 and patients classified into two groups.

Group I: 652 patients who used venous catheters for acute HD prescription; subdivided into three subgroups.

Six hundred patients (360 males and 240 females) used femoral vein catheterization, 500 patients used single lumen catheters and 100 patients used double lumen catheters.

Thirty patients with internal jugular vein catheterization (22 males and 8 females).

Twenty-two patients with subclavian vein catheterization (15 males and 7 females).

Our greater use of femoral catheters was due to our belief that they are the safest temporary access method, in accordance with Weyde et al (6) who reported that femoral vein cannulation is the safest acute VA method.

The single lumen catheters were 500 radiopaque polyurethane catheters sterilized by ethylene oxide (Amecomedical Cairo, Egypt) and the double lumen catheters were 100 dual-lumen catheters. Most acute catheters were made of polyurethane (16).

In the femoral vein approach the patient was placed flat on his back with the knee slightly flexed and the thigh abducted and rotated outward. The femoral vein is located 2-4 cm below the inguinal ligament. The catheters were inserted using an aseptic technique, while the operator wore a sterile surgical gown and gloves, and the skin disinfected with 2% chlorhexidine. A single lumen catheter was probed with an 18 gauge needle. For double lumen catheters, a 16 gauge probing needle was used to enter the vein with gentle aspiration during the advancement of the needle. Dark red blood entering the needle indicated entry into the vein. Once the needle entered the vein, a guidewire was promptly inserted. The needle was then removed. To enlarge the tract a dilator was used for the double lumen catheter (10-11 F). Single lumen catheters were introduced without a dilator.

An uncuffed femoral catheter can be used several times within 2-3 days, but the patient must remain at bed rest as long as the catheter is in place. After 72 hr the catheter should be removed (5).

In the internal jugular vein approach, the right side was preferred as the dome of the lung and pleura is lower on the right side than on the left side, the right internal jugular vein travels in a relatively straight path to the atrium and the thoracic duct, on the left side, is not endangered.

In the subclavian vein approach, the skin just below the clavicle at the junction of the middle and inner third is anesthetized. Aiming for the jugular notch, the probing needle was advanced under the clavicle and mild suction applied to the syringe as it was inserted.

Group II: patients who used an AVF for chronic HD prescription. Eighty patients with ESRD on chronic regular HD thrice weekly for variable intervals, 49

males and 31 females, their mean age ± SD was 43.6 ± 12.2 yrs (range 18-68 yr), HD duration was ± SD 4.2 ± 3.1 yrs. They were classified into two subgroups.

A) Thirty-two patients already having an AVF. HD duration was ± SD 4.8 ± 2.2 yrs.

B) Forty-eight patients subjected to AVF surgery during the study period. HD duration was ± SD 2.1 ± 1.3 yrs.

Group II patients were subjected to the following:

1) thorough history and clinical evaluation of the target limb arterial system;

2) radiological work up using a 7.5 Mhz linear probe Medison 9900C unit. In particular, we used:

a) a gray scale mode to obtain morphologic criteria of the investigated arteries, namely the diameter and cross-sectional area of the axillary artery and vein, brachial artery and radial artery;

b) color Doppler ultrasound to estimate the hemodynamic parameters including blood flow volume (velocity X, cross-sectional area together with the automatically calculated resistivity index of the inflow artery). The fistula itself was examined for flow velocity, flow volume and cross-sectional area. Three parameters were determined at the fistula site: 1 - peak systolic velocity (m/sec); 2 - fistula flow rate (ml/min); 3 - resistivity index.

## RESULTS

In group I femoral vein cannulation complications included bleeding from a femoral artery tear in six patients, as noted by a gush of arterial blood. This could have been due to the rapid withdrawal of the guidewire when it was not free to move back and forth after it was fully inserted, but a wall laceration of the femoral artery was successfully repaired surgically in these patients. Another complication was bleeding from a punctured femoral artery, which was treated by local pressure for 15 min without any problems.

We undertook a prospective observational study to determine catheter infection and removal rates that were high, 240 patients (40%). We could not identify risk factors for catheter-related infections, but it could have been due to the migration of the patient's flora through the punctured site or catheter contamination by patient manipulation. Other complications included three groin hematomas (0.5%) and 45 catheter thromboses (7.5%), which accounted for the initial catheter dysfunction and could need catheter removal (Tab. I). Patients who began HD with an AVF had an 83% survival to 12 months, while those who began HD with a catheter had a 60% survival rate.

In the internal jugular vein approach (30 patients), infection was found in six patients (20%) and four of them were diabetic; thrombosis in nine patients (30%); and accidental withdrawal in two patients, in spite of fixation by suture (Tab. II).

In subclavian vein cannulation (22 patients) catheter dysfunction was found in 7 patients (31.8%) (absence of flow from the catheter lumen due to thrombosis or catheter kinking) and infection in 10 patients (45.4%) (Tab. III). Early complications were the inability to cannulate the vein in three patients and they were switched to femoral vein cannulation and excluded from the study.

Group II: were classified into subgroup A (patients already with an AVF), 32 patients. AVF were performed by side-to-side technique, 18 patients with a radiocephalic fistula, 6 patients with a brachiocephalic fistula due to radiocephalic fistula failure, and 8 patients with a brachiobasilic fistula due to brachiocephalic fistula failure. All brachiobasilic fistulae were successful.

Subgroup B (AVF created during the study period), 48 patients; radiocephalic fistulae in 27 patients, brachiocephalic fistulae in 9 patients and brachiobasilic fistulae in 12 patients.

Doppler ultrasound showed AVF stenosis in 15 patients from both groups who required re-operation. Resistivity index reduction to <0.1 (cut-off point) was observed in the 15 patients with fistula stenosis. Successful range of fistula flow rate was considered

**TABLE I** - COMPLICATIONS OF THE FEMORAL VEIN APPROACH

| Complication | Number of patients | % |
|---|---|---|
| Bleeding from a femoral artery tear | 6 | 1% |
| Bleeding from a femoral artery puncture | 30 | 5% |
| Catheter infection | 240 | 40% |
| Groin hematoma | 3 | 0.5% |
| Catheter thrombosis | 45 | 7.5% |

230-400 ml/min. A blood flow rate <200 ml/min suggested low fistula flow. Peak velocity was used mainly to assess flow (significant stenosis caused a doubling of the peak velocity) (Tab. IV).
Clinically, we found limb edema in 14 patients, hematoma in 5 patients, accidental trauma by the patient himself lead to fistula failure in 2 patients. Fifteen patients underwent reconstruction of 2 AVF during the study period, 20 patients of 3 AVF and 2 patients of 4 AVF. Mean AVF survival was 30 ± 19 months.
There was no significant difference between AVF survival rates of males vs. females (p=0.62), anemic vs. non-anemic patients (p=0.53) (anemia was defined as Hb <11 g/dl), AVF survival was better for hypertensive vs. normotensive patients (p<0.05), AVF malfunction correlated significantly with HD duration (p<0.05).

## DISCUSSION

In acute HD, prescription complications included bleeding from a femoral artery wall laceration due to rapid guidewire withdrawal when it was not free to move back and forth after it was fully inserted, and bleeding from a punctured femoral artery, which was treated by local pressure for 15 min.
The catheter infection rate was high and this was evidenced by crust erythema, rarely, pus can be expressed from the catheter tract at the exit site. This is in agreement with the results of Hung et al (17), Kite et al (18) and Weyde et al (6) who observed exit site infection in 14.2% of their patients. In addition, Oliver et al (19) reported that the bacteremia incidence was 1.9% 1 day after femoral vein catheter insertion, but increased to 13.4% by the 2nd day if the catheter was not removed.
Barracca et al (20) demonstrated that temporary catheter use had increased the infection risk and that fever was present in 5.5% of patients with a femoral catheter. Webb et al (21) reported that 100 catheters were inserted in 82 patients and nine catheters were lost due to infection. Al-Wakeel et al (22) found catheter infection in 31/96 patients.
We found catheter thrombosis in 45 patients, although the dead space of each lumen was filled with heparin (5000 unit/ml) through the injection port. This could be due to the bad quality of the catheter material or to infection. This is in agreement with the results of Bloz et al (23), Diskin et al (24), and Weyde et al (6) who reported that the catheter thrombosis incidence was 17.1%. In addi-

**TABLE II** - COMPLICATIONS OF THE INTERNAL JUGULAR VEIN APPROACH (30 PATIENTS)

| Complication | Number of patients | % |
|---|---|---|
| Infection | 6 | 20% |
| Thrombosis | 9 | 30% |
| Accidental withdrawal | 2 | 6.6% |

**TABLE III** - COMPLICATIONS OF THE SUBCLAVIAN VEIN APPROACH (22 PATIENTS)

| Complication | Number of patients | % |
|---|---|---|
| Catheter dysfunction | 7 | 31.8% |
| Infection | 10 | 45.4% |

**TABLE IV** - DIAGNOSTIC CRITERIA OF SUCCESSFUL OR STENOSED FISTULA

| Index | Successful fistula | Stenosed fistula |
|---|---|---|
| Flow ml/min | 220-400 | <200 |
| Resistivity index | > 0.1 | <0.1 |
| Peak velocity | 0.6-1 m/sec | >1.5 m/sec |

tion, Webb et al (21) found that >80% of femoral catheters required anticoagulation. Al-Wakleel et al (22) reported catheter thrombosis in only 4/96 patients. Contrary to our results, Daeihagh (25) did not encounter the problem of catheter thrombosis. This could be due to tissue plasminogen activator use while we used heparin. Other complications in our study included three groin hematomas, and bleeding from the femoral artery in six patients. This was similar to the complications found by Al-Wakeel et al (22).

Our results showed that patients who began HD with an AVF had a higher survival rate than those who began HD with a catheter insertion. These results agree with those of Ziegler et al (26). In addition, our results agree with those of Van Waeleghem (27) who reported that any access inadequacies would create dialysis insufficiency leading to more comorbid conditions and even higher mortality. Canaud et al (28) also reported that venous catheters provided reduced flow performances and dialysis doses compared to AVF (5-6%).

Branger et al (29) reported that thrombosis was frequent, infection was observed and accidental withdrawal occurred in 11% of cases, in agreement with our results. Quarello et al (30) reported that a possible future routine utilization of the jugular vein is advisable to allow a new AVF to mature. According to our results we recommend AVF creation before HD starts. In agreement with our results, Dhingra et al (2) reported that patients with central venous catheters had a higher associated mortality when compared with AVF, due to increased infections. In addition, Pastan et al (31) found that the infection risk increased to the extent that it was associated with an increased risk of death among HD patients. The proportion of deaths was greater among those who were dialyzed with venous catheters (16.8%) compared to those dialyzed with an AVF (7.3%).

Kamaran et al (32) reported that among the patients who underwent subclavian vein catheterization, 21.9% of catheters had to be replaced due to various complications, for example, thrombosis, infection, or catheter kinking. Early complications encountered were arterial puncture in 10.7%, inability to cannulate the innominate vein in 16.5%, hemothorax in 0.5%, puncture of the thoracic duct in 0.2%, hemo-mediastinum in 0.6%; arrhythmia and pulmonary hematoma in 0.2%, early infection in 15% of catheterizations and delayed infection in 39% of cases. These data are in agreement with our results.

Maskova et al (33) reported that central vein stenosis and occlusion were associated with previous subclavian vein cannulation. In addition, in agreement with our results, Saeed Abdulrahman et al (34) reported that the infection rate was higher in HD patients with temporary access compared to those with a permanent AVF.

Various methods have been proposed to detect abnormal access flow. These include clinical evaluation, angiography and color duplex study. Clinical evaluation performed by auscultation and palpation is not generally believed to be reliable, because it can be imprecise and examiner dependent. Angiography, although accurate, is invasive and can cause thrombosis. It also can cause discomfort and possible injury to access function. Color Doppler imaging is gaining acceptance because it is accurate and non-invasive. It offers certain additional advantages, including portability, low cost, and a lack of exposure to radiation (35).

Measurement of the resistivity index reflects the degree of vascular resistance across the fistula. El Gebaly et al (36) reported that the increase in the resistivity index of >0.1 ensures a high success rate. On the other hand, with a reduction in the resistivity index to <0.1 a much lower rate is obtained. This is in agreement with our results.

The mean blood flow volume in patients with successful fistulae ranged from 220-400 ml/min. This is in agreement with Miller et al (37), as they suggested that a blood flow rate of 250-350 ml/min is essential for adequate HD.

## CONCLUSIONS

Patients who began HD with a catheter had more complications and higher mortality than those who began with an AVF. Therefore, early referral is necessary for permanent AVF placement. The restriction of VA procedures to surgeons with a demonstrable interest and experience is recommended, as well as routine quality assessment of AVF fistula by Doppler imaging. A more restricted use of venous catheters would result in less morbidity and in a cost reduction.

It is necessary to try to implement the correct measures for patients to allow them to start HD with a permanent AVF. Therefore, we recommend early referral to dialysis centers, as late referral is considered one of the HD problems in our region.

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